Fashions in turbulence theory.

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Back in the 1980s, fractals were all the rage. They were going to solve everything, and turbulence was no exception. The only thing that I can remember from their use in microscopic physics was that the idea was applied to the problem of diffusion-limited aggregation, and I’ve no memory of how successful they were (or were not). In turbulence they were a hot topic for solving the supposed problem of intermittency, and there was a rash of papers decorated with esoteric mathematical terms. This could be regarded as ‘*Merely corroborative detail, intended to give artistic verisimilitude to an otherwise bald and unconvincing narrative*.’[1]. When these proved inadequate, the next step was *multi*fractals, which rather underlined the fact that this approach was at best a phenomenology, rather than a fundamental theory. And that activity too seems to have died away.

Another fashion of the 1970s/80s was the idea of deterministic chaos. This began around 1963 with the Lorentz system, a set of simple differential equations intended to model atmospheric convection. These equations were readily computed, and it was established that their solutions were sensitive to small changes in initial conditions. With the growing availability of desktop computers in the following decades, low-dimensional dynamical systems of this kind provided a popular playground for mathematicians and we all began to hear about Lorentz attractors, strange attractors, and the butterfly effect. Just to make contact with the previous fashion, the phase space portraits of these systems often were found to have a fractal structure!

In 1990, a reviewer of my first book [2] rebuked me for saying so little about chaos and asserted that it would be a dominant feature of turbulence theory in the future. Well, thirty years on and we are still waiting for it. The problem with this prediction is that turbulence, in contrast to the low-dimensional models studied by the chaos enthusiasts, involves large numbers of degrees of freedom; and these are all coupled together. As a consequence, the average behaviour of a turbulent fluid is really quite insensitive to fine details of its initial conditions. In reality that butterfly can flap its wings as much as it likes, but it isn't going to cause a storm.

In fairness, although we have gone back to using our older language of 'random' rather than 'chaotic' when studying turbulence, the fact remains that deterministic chaos is actually a very useful concept. This is particularly so when taken in the context of complexity, and that will be the subject of our next post.

[1] W. S. Gilbert, The Mikado, Act 2, 1852.
[2] W. D. McComb. The Physics of Fluid Turbulence. Oxford University Press, 1990.